REMARKS

By the present amendment product claims 1 to 4 and 10 are under consideration in the application. Claims 1 and 10 are independent claims. Method claims 5 to 9 have been withdrawn from consideration due to the restriction requirement.

Restriction Requirement

In response to the restriction requirement, applicants hereby affirm the election of claims 1 to 4 for further prosecution in the application.

This election is made without prejudice to the filing of a division application directed to non-elected claims 5 to 9.

Applicants submit that new independent claim 10 of the present amendment is a steel sheet product claim which is properly a member of elected Group I, i.e., claims 1 to 4.

Support For Claim Amendments

Claim 1

Hot rolling is disclosed, e.g., in the specification at page 13, lines 11 to 14 and page 14, lines 6 to 7.

Bainitic ferrite and bainite are disclosed in the specification, e.g., at page 8, lines 25 to 35.

Claim 10

New independent claim 10 is based upon independent claim 1.

The claim limitation "and the bainitic ferrite and bainite structures contained in the hot-rolled steel sheet before welding not including carbides inside ferrite laths and between ferrite laths other than Ti and Nb carbide" is disclosed in the specification, e.g., at page 9, lines 1 to 3.

§102/§103

Claims 1 and 2 were rejected under 35 U.S.C. §102 (a) as being anticipated by U.S. Patent No. 6,632,295 to Nakata et al.

Claims 1, 2 and 4 were rejected under 35 U.S.C. §102(a) as being anticipated by U.S. Patent No. 6,666,932 to Funakawa et al.

Claim 3 was rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,632,295 to Nakata et al. or U.S. Patent No. 6,666,932 to Funakawa et al. in view of U.S. Patent No. 4,388,122 to Sudo et al.

These rejections, as applied to the amended and new claims of the present amendment, are respectfully traversed.

Background

Materials generally become worse in formability the higher the strength. The improvement of burring becomes a topic in the use of high strength steel sheet for auto parts. Auto parts are comprised of press formed and other worked members assembled together by spot, arc, plasma, laser and other welding. The weld strength at the time of forming or the time of use of an assembled part is extremely important from the viewpoints of the forming limits and safety. Therefore, in the application of high strength steel sheet to auto parts etc., the burring and the weld zone strength also become important issues for study. (See: specification, pages 2-3).

The Present Invention

The present inventors discovered that high burring, high strength, hot-rolled steel sheet having a microstructure composed of ferrite or ferrite and bainite is extremely excellent in burring, but has a weld heat affected zone (HAZ) which remarkably softens. A material obtaining strength by a bainitic microstructure sometimes softens at the HAZ in an arc welding or other welding thermal cycles. The present inventors discovered that Mo or Cr clusters or precipitates with C and other elements in welding or another short thermal cycle raise the strength and as a result suppress the softening of the HAZ.

"Bainitic ferrite and acicular ferrite structures" referred in the present invention means structures not including carbides inside ferrite laths and between ferrite laths and between ferrite laths other than Ti and Nb carbides. A characteristic feature of the present invention is that the present inventive bainitic ferrite microstructure does not include carbides inside ferrite laths and between ferrite

laths other than Ti and Nb carbides in the hot-rolled steel sheet, and an amount of C* (C* = C - (12/48Ti - 12/14N - 12/32S) is more than 0 for clustering or precipitating Mo or Cr with C in the welding cycle. If the Mo carbides are precipitated in the hot-rolled steel sheet, the value of effective C* is below 0, even if the value of C* defined by the present invention exceeds 0. As a result, softening of HAZ cannot be restrained.

Therefore, it is necessary to control the bainitic ferrite microstructure in the hot-rolled steel sheet not to include carbides inside ferrite laths and between ferrite laths other than Ti and Nb.

Attachment A hereto is two drawings illustrating the microstructure. Fig. 1 of Attachment A shows a photograph of a bainitic ferrite microstructure having a grain size of less than 1 μm in the hot-rolled steel sheet. Fig. 2 of Attachment A hereto shows a photograph of a polygonal ferrite microstructure having a grain size of 3-4 μm in the hot-rolled sheet.

The present inventors confirmed, through further extensive experiments regarding tensile test after welding shown in Table 2 and burring test (λ), that if the hot-rolled steel sheet contains the appropriate amount of C, Si, Mn, P, S, Al, N, Ti, (Nb), Cr, Mo, and the appropriate amount of C* and Mo + Cr, the resultant hot-rolled steel sheet obtained has a microstructure composed of only bainitic ferrite and bainite, and has a tensile strength of more than 603 MPa, more than 90% of λ, and Hv less than 40 regarding the softening HAZ.

Regarding a production process, a finishing temperature of the hot-rolling must be performed at more than Ar3 + 30°C for obtaining a bainitic structure. If the finishing temperature is less than Ar3 + 30°C a polygonal ferrite structure is formed. It is necessary to control the other production conditions, such as retaining temperature, cooling rate, coiling temperature as defined by the present invention for obtaining a further refined bainitic ferrite structure. During these conditions, it is necessary to

control the bainitic structures as not including carbides inside ferrite laths and between ferrite laths other than Ti and Nb carbides.

A key technology of the present invention is that weldability is improved by controlling Ti and Nb precipitation even if the steel contains Mo. The precipitation site of the Ti and Nb is in the ferrite lath and in between the ferrite lath acting on the burring property, in addition to improving the burring property by means of forming a structure composed of bainitic ferrite and bainite.

Patentability

USP 6,632,295 ('295 patent)

The '295 patent relates to a 490 MPa high tensile strength hot-rolled steel sheet having excellent workability, high magnetic permeability and high magnetic flux density in a strong magnetic field and is used for large electric equipment such as a rotor of a generator.

Regarding the microstructure obtained by '295 patent, it can be seen that polygonal ferrite grain size is more than 3 μm from claim 1. On the other hand, the present invention does not have the properties, such as high magnetic permeability and high magnetic flux density, in a strong magnetic field. Further, a microstructure defined by the present invention is bainitic ferrite structure having a grain size less than 1 μm. In addition, the hot-rolled steel sheet according to the present invention is used in auto parts which is quite a different use than a use in large elctric equipment such as a rotor of generator as mentioned in '295 patent.

Therefore, the hot-rolled steel sheet of the present invention is quite different from the steel sheet obtained by '295 patent in the points of the microstructure, desired properties and use.

Regarding a production process, '295 patent clearly mentions that the steel must be finished hot rolling at a temperature of more than Ar3 transformation point and lower than 880°C for obtaining a uniform structure. On the other hand, the present invention defines a hot-rolling finishing temperature of more than Ar3 + 30°C, and an actual hot-rolling

finishing temperature of more than 910°C to 950°C (See: Table 2) which is higher than that of '295 patent. Therefore, a person skilled in the art cannot conceive the hot rolling conditions required for the present invention from the teachings of '295 patent.

Although Table 1, No. 7 steel in the '295 patent has the same steel composition as that of the present invention, this steel is excluded from the scope of '295 patent because it has low magnetic permeability and magnetic flux density. Further, the ferrite grain size based on the steel composition shown in Table of '295 patent is about 10 μm, which is a polygonal ferrite structure which is quite a different microstructure from the bainitic ferrite structure defined in the present invention.

USP 6,666,932 ('932 patent)

The '932 patent relates to a high strength, hot rolled steel sheet composed of a ferrite single phase microstructure having excellent in elongation and flangeability. However, the '932 patent clearly mentions that sufficient elongation cannot be obtained with the existence of the bainitic ferrite structure with high dislocation density (See: column 1, lines 39-41). The '932 patent further mentions that high elongation cannot be obtained because of a fine grain size of ferrite of 2 μm or smaller (See: column 1, lines 57 - 60).

From these statements, the '932 patent is only directed to a hot rolled steel sheet having ferrite structure other than bainitic ferrite and large grain size of more than 2 μm, which is totally different from the present invention.

Regarding the precipitates, the '932 patent targets to finely precipitate composite carbides composed of Mo and Cr in the hot rolled steel sheet for improving elongation and flangeability. On the other hand, in the present invention, carbides contained in the bainitic ferrite structure are carbonitrides composed of Ti and Nb. If C* is more than 0, high strength can be improved by Mo or Cr with C for clustering or precipitating at HAZ in the welding cycle.

However, in case of the '932 patent, a certain amount of C is fixed as Mo precipitates because Mo carbide is already precipitated in the hot rolled steel sheet even if C* exceeds 0. Therefore, the amount of solute C is below 0 under the condition of C* exceeding 0, there is less amount of Mo for clustering or precipitating during welding because of the already formed Mo carbide in the hot rolled steel sheet. Therefore, it is very hard to restrain softening of the HAZ portion, As a result, the '932 patent does not teach or suggest the strength at HAZ portion of the present invention.

Regarding a production process, the present invention defines that the cooling rate after hot rolling is more than 50°C/sec and less than 300°C/sec for precipitating only carbonitrides of Ti and/or Nb. However, '932 patent does not clearly mention the specific cooling rate, and only discloses Mo which has slow diffusion speed forms carbides with Ti. This means that composite carbides including Ti and Mo precipitate. Therefore, in case of '932 patent, hot rolling finishing temperature, cooling rate and coiling temperature are strictly controlled for precipitating Mo as Mo carbide. As a result, these production conditions are quite different from that of the present invention, in addition to the quite different metallic structure, especially bainitic ferrite and grain size.

USP 4,388,122 ('122 patent) relates to a method of making high strength, hot rolling steel sheet having excellent flash butt weldability, fatigue characteristics and formability and having composite microstructure composed of polygonal ferrite and bainite. This microstructure is different from the microstructure composed of only bainitic ferrite and bainite, as in the present invention. In the present invention, polygonal ferrite must be avoided because of deteriorating hole expandability.

In the Examples, Steel H, K, L containing Cr and/or Mo are different steels from the present invention because they are outside ranges of C* value, more than 0.05%.

Fig. 3 of Attachment B shows a relationship between burring property (%) and tensile strength. In attached Fig. 3, it is clearly seen that the tensile strength according to the present invention is superior to that of the '122 patent. Therefore, the present invention is quite different from the technology disclosed in the '122 patent.

It is therefore submitted that independent claims 1 and 10 of the present amendment, and all claims dependent thereon, are patentable over the '295 patent, the '932 patent and/or the '122 patent standing alone or in combination.

CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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Dated: November 21, 2007

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